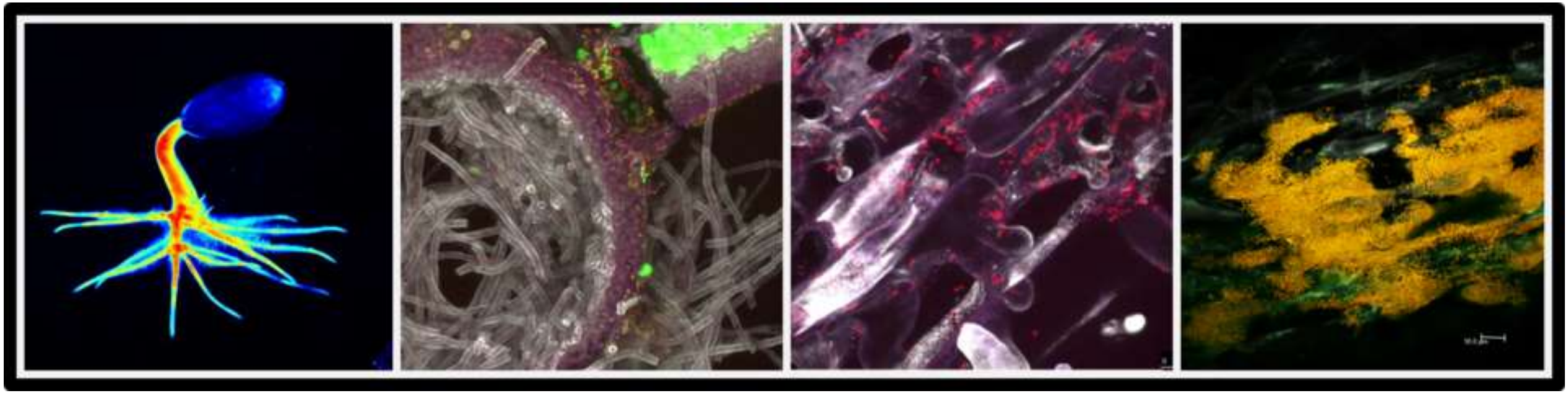
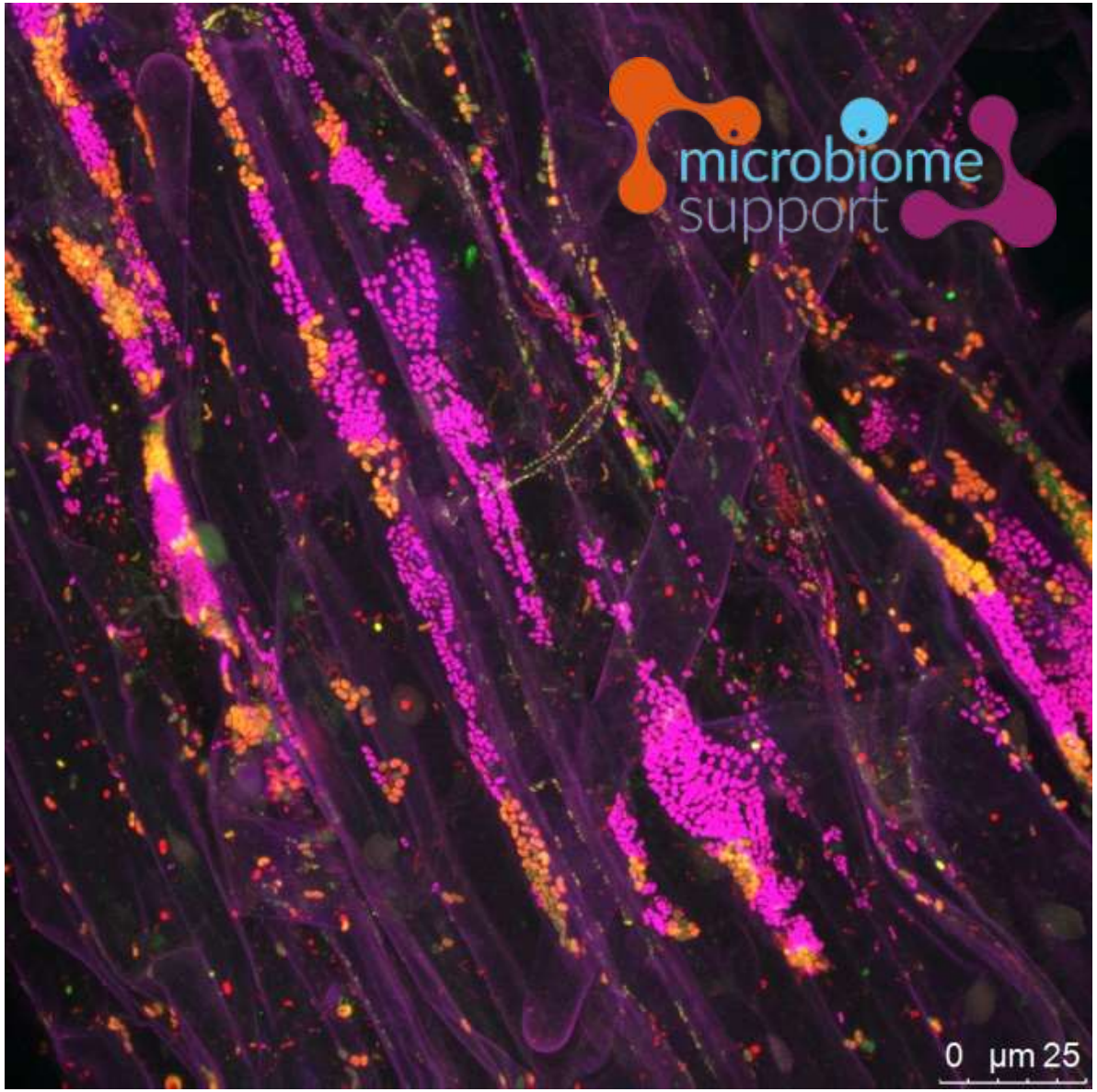
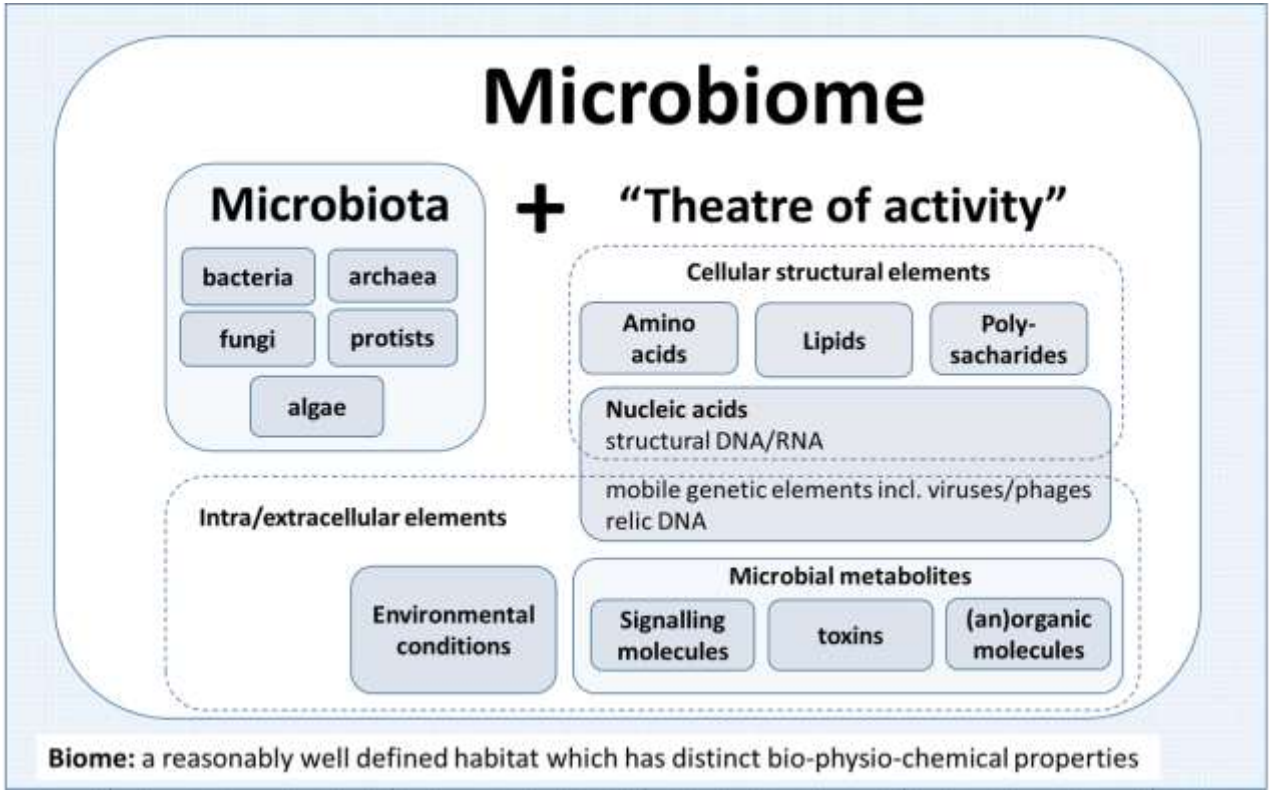


Exploring the plant microbiome for managing pathogens and resistances

Gabriele Berg
Environmental Biotechnology
TU Graz AUSTRIA

INTRODUCTION: Microbiome research – a new field in science

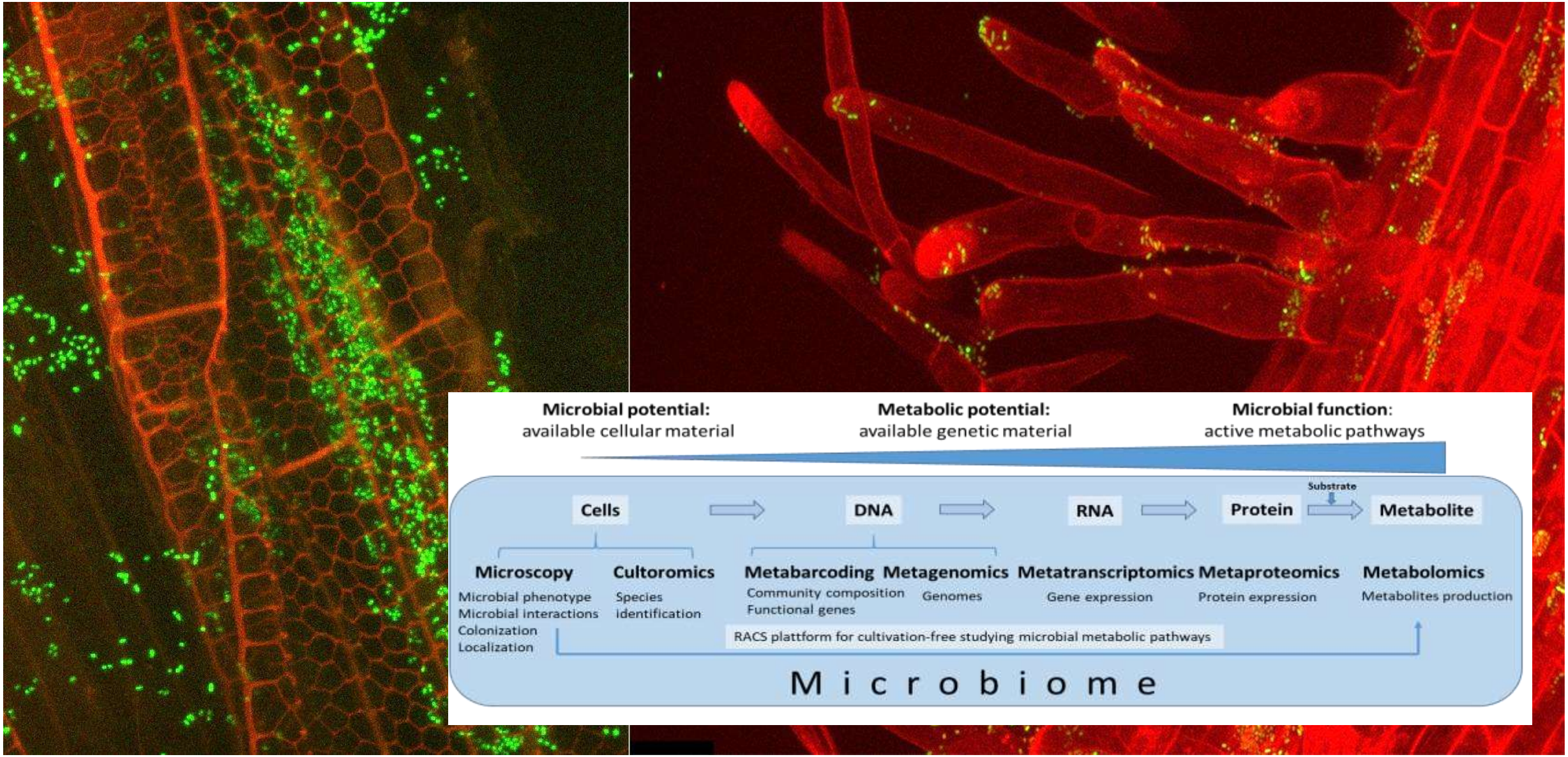




MICROBIOME = microbial community occupying a reasonably well defined habitat which has distinct physio-chemical properties. The term thus not only refers to the microorganisms involved but also encompasses their theatre of activity.

JM Whipps et al. 1988

INTRODUCTION: Studying the fruit microbiome



PROBLEM: Biodiversity loss world-wide

Anthropocene:

Human activity and intense agriculture caused:

- ✓ **altered biogeochemical cycles**
- ✓ **species extinctions 100 to 1,000 times higher**
- ✓ **1,000,000 species threatened with extinction**

ipbes
Science and Policy for People and Nature

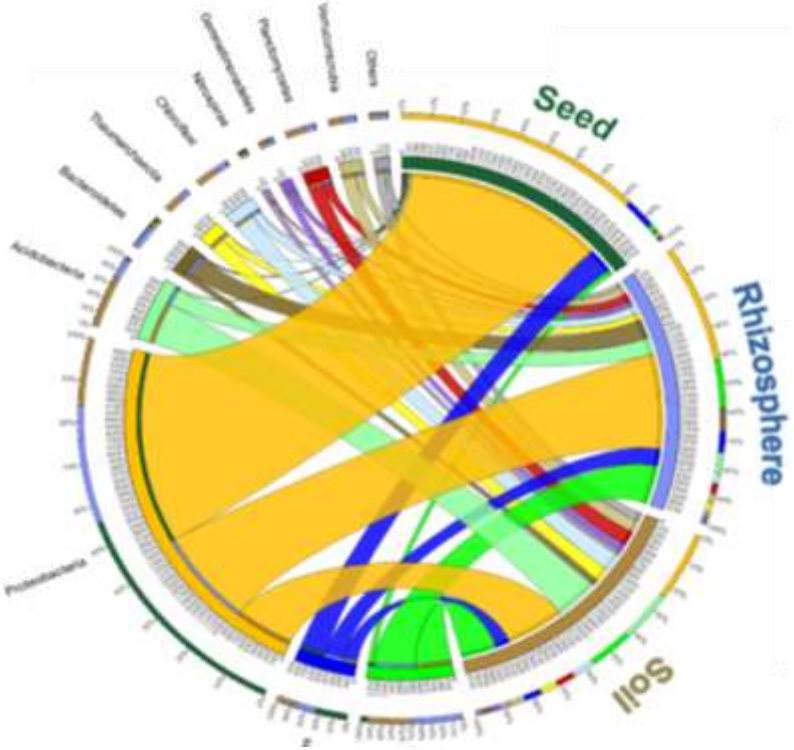
Increasing problems to control pathogens and resistances

1. Which microbial diversity is associated with plants (seed/fruit)?

2. Is it possible to manage pathogens and resistances?

1. Which microbial diversity is associated with pumpkins?

Type	Denomination	Pedigree	Geographic origin	Seed samples
Homozygous inbred lines	Line A - D	-	Austria	
Single cross hybrid	Gleisdorfer Diamant	Line A x Line B	Austria	
Three-way cross hybrids	GL Opal GL Rustikal	Gl. Diamant x Line C Gl. Diamant x Line D	Austria	
Population cultivar	GL Classic	-	Austria	
Single cross zucchini hybrid	Naxos	-	Netherlands	
Segregating breeding lines	Line E – I	-	Germany, Slovenia, China	

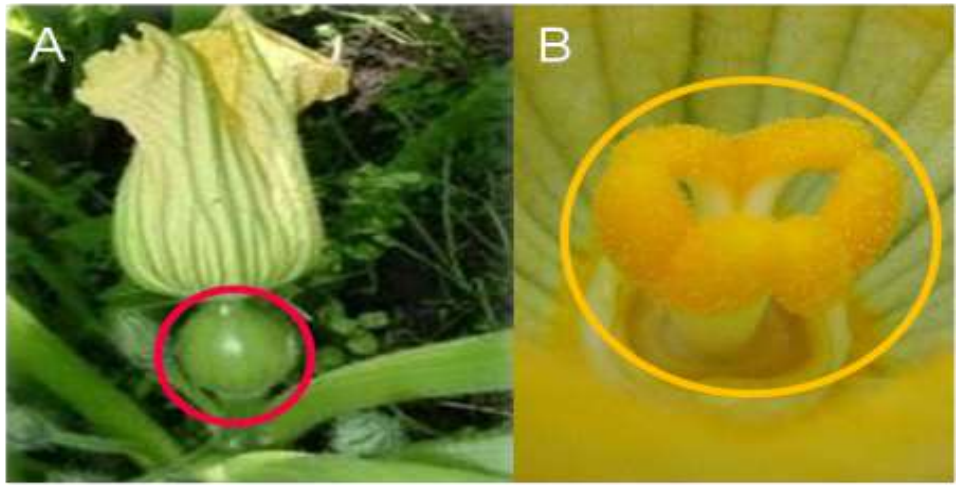


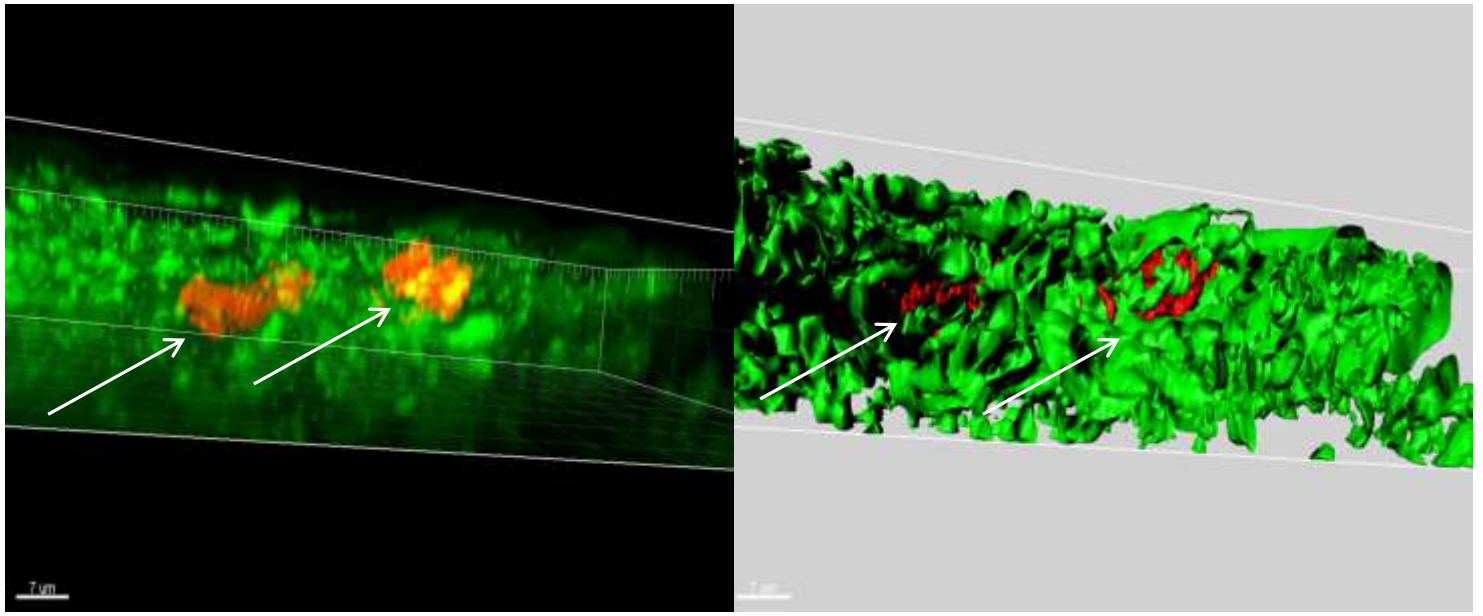
The microbiome was shaped by breeding
The microbiome correlated with resistance against

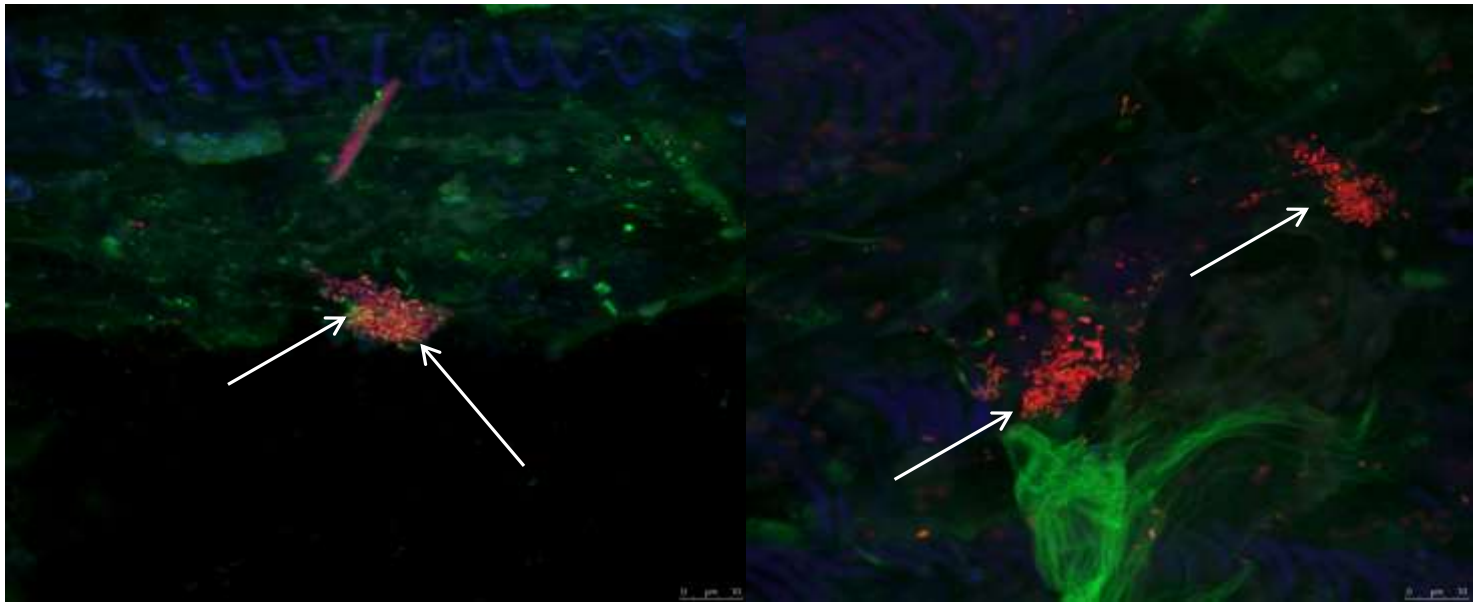
- ***Erwinia carotovora Enterobacteriaceae***

[Adam *et al.* Plant and Soil 2016]

1. Which microbial diversity is associated with pumpkins?

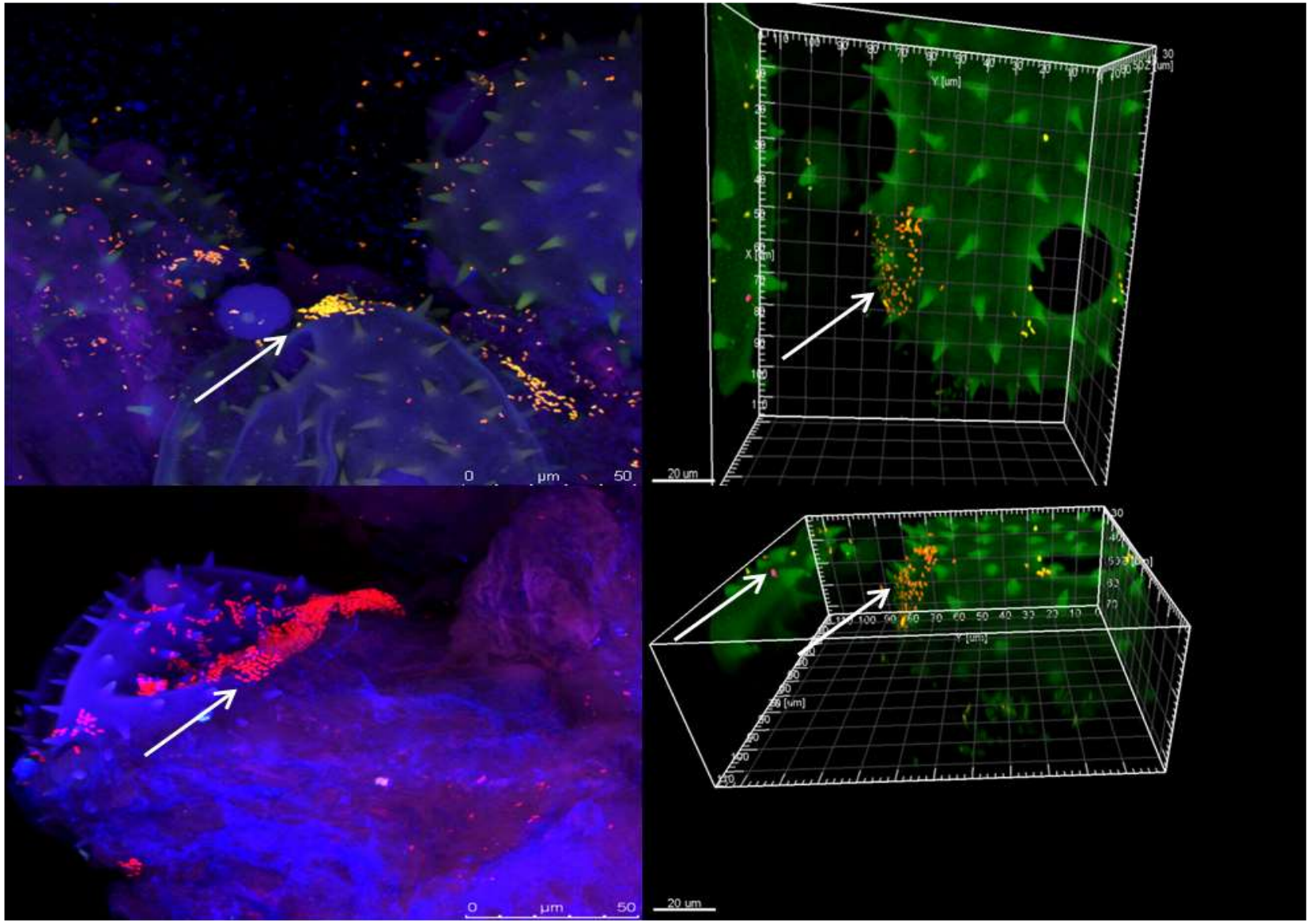






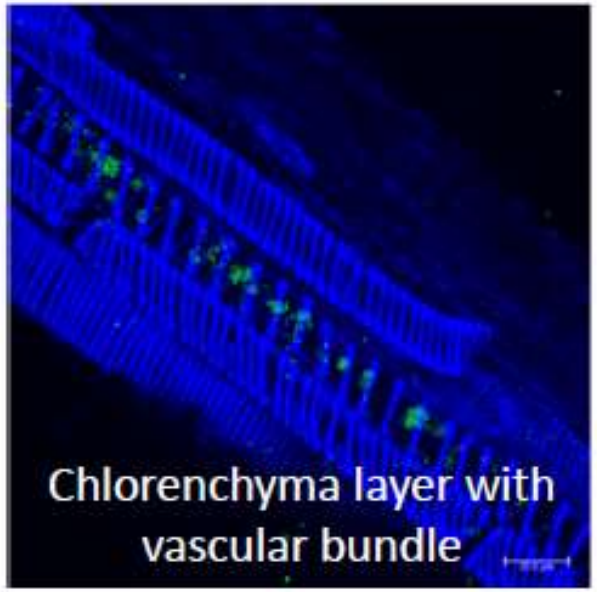
Bacteria on the petal of the withered female oil pumpkin flower visualized by CLSM and FISH. 3D construction by the software IMARIS.

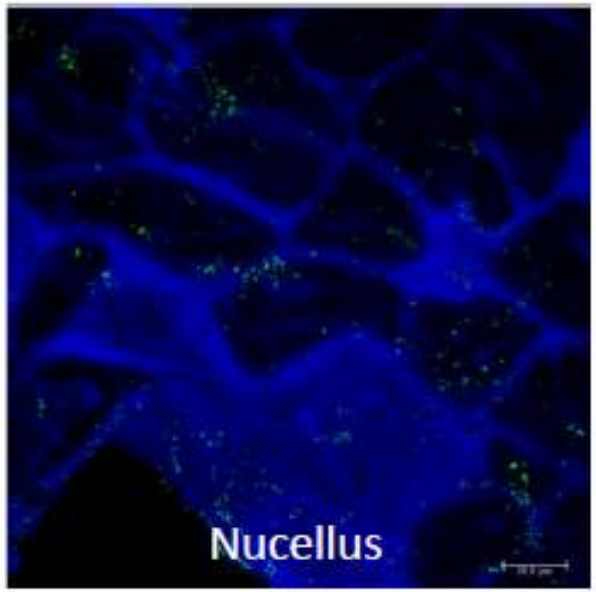
1. Which microbial diversity is associated with pumpkins?

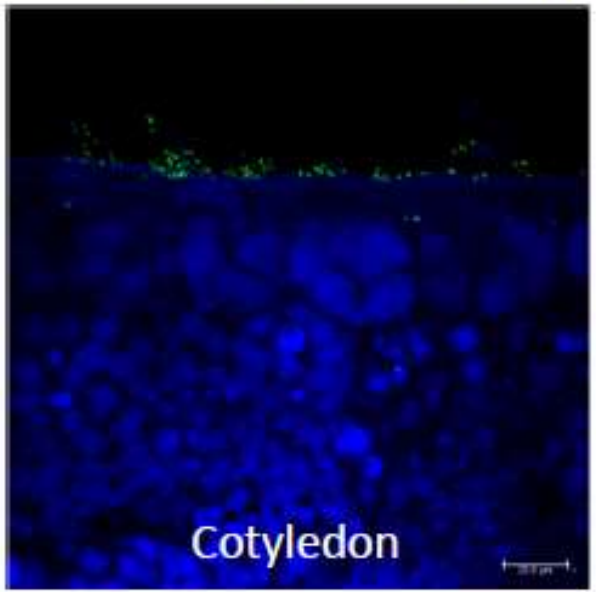


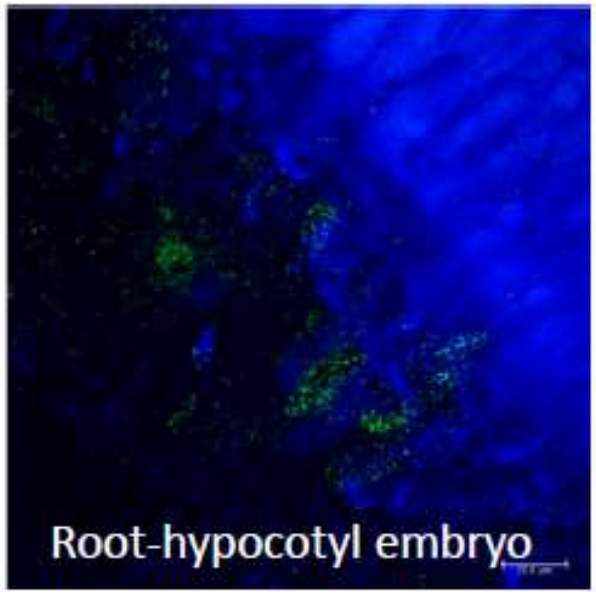
Bacteria on the pollen grains on the pistil of the withered female oil pumpkin flower by CLSM and FISH.

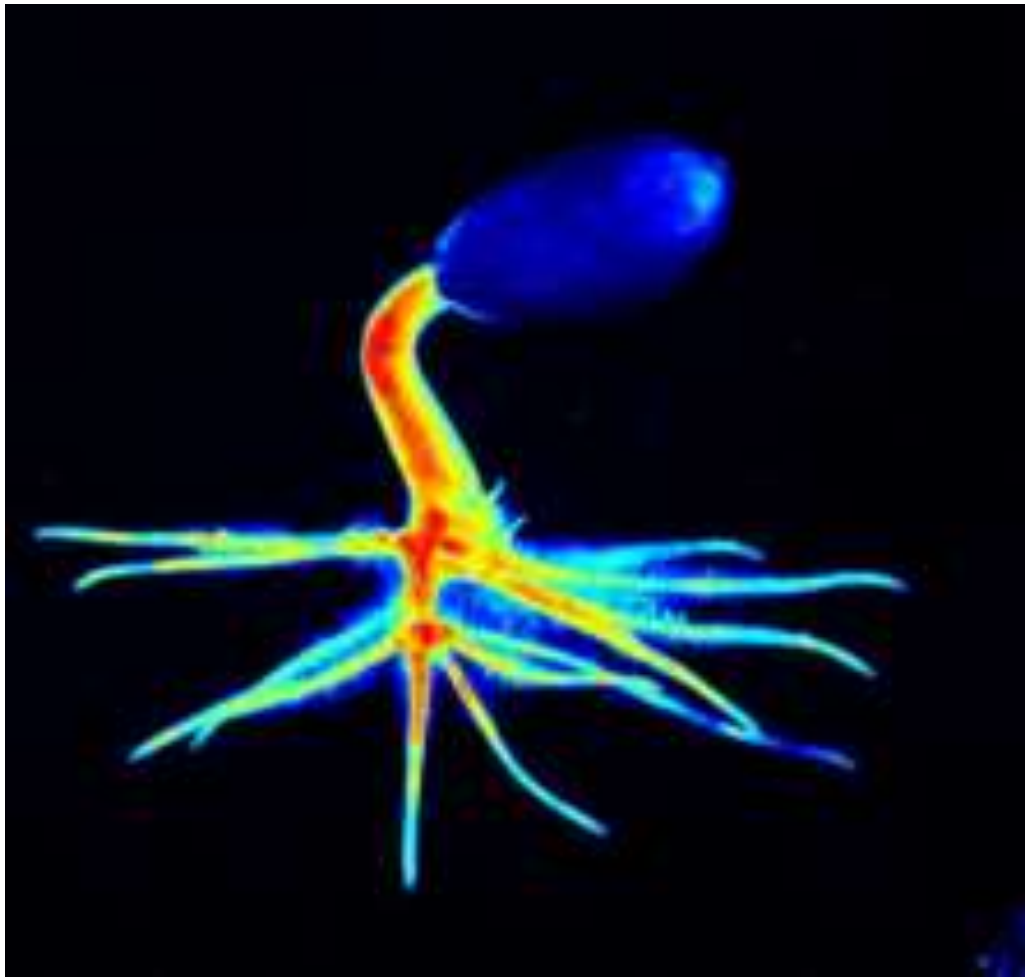
1. Which microbial diversity is associated with pumpkins?











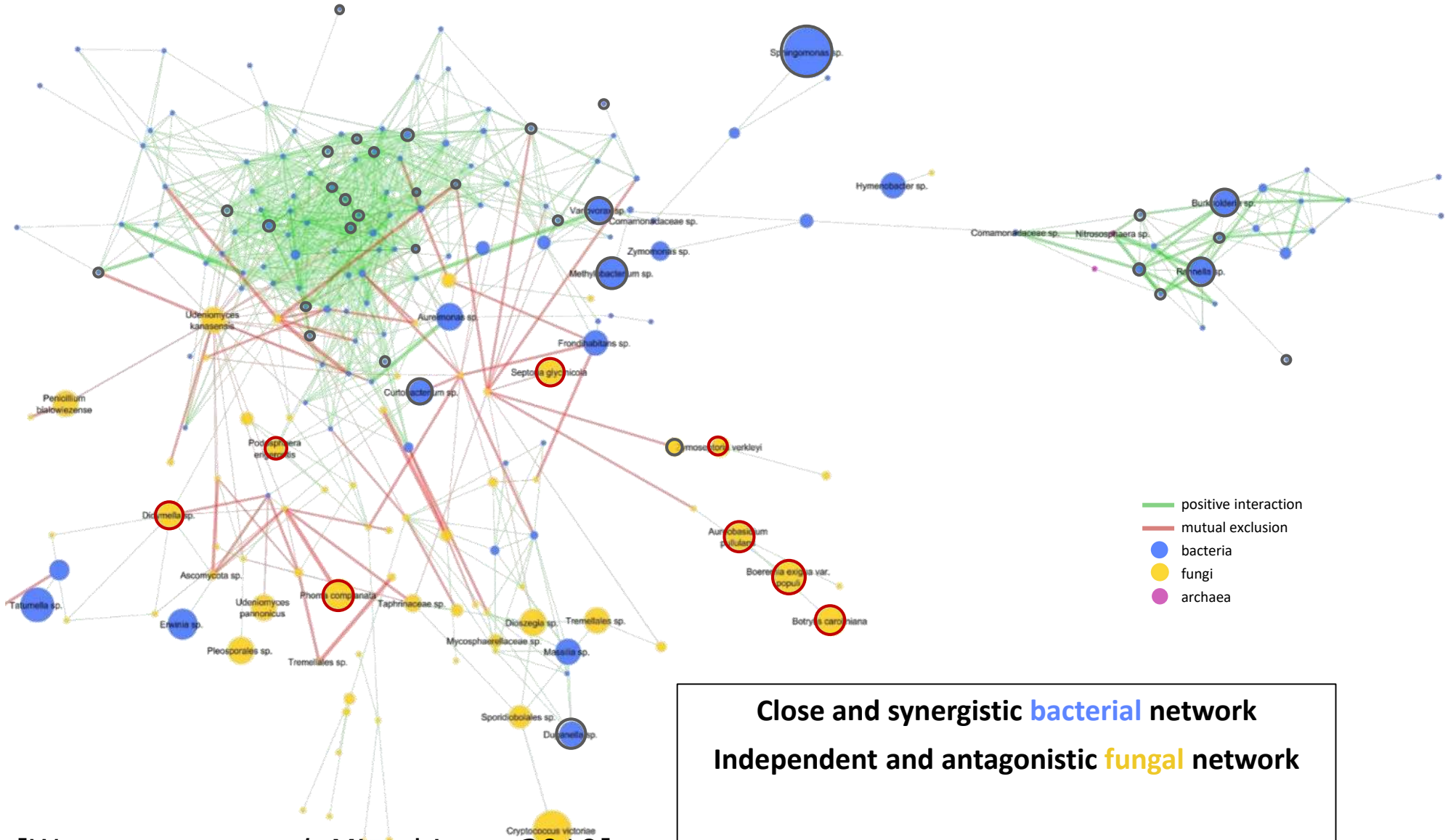
The Native Alpine Seed Microbiota








1. Which microbial diversity is associated with native plants?



BACTERIA:
11 shared OTUs
out of
11,844 OTUs

FUNGI:
5 shared OTUs
out of
3,943 OTUs

- ***Botrytis***
- ***Didymella***
- ***Phoma***
- ***Septoria***
- ***Udeniomyces***

ARCHAEA:
unique

Close and synergistic bacterial network

Independent and antagonistic fungal network

[Wassermann *et al.* Microbiome 2019]

CONCLUSION: The plant microbiome

The Plant microbiome

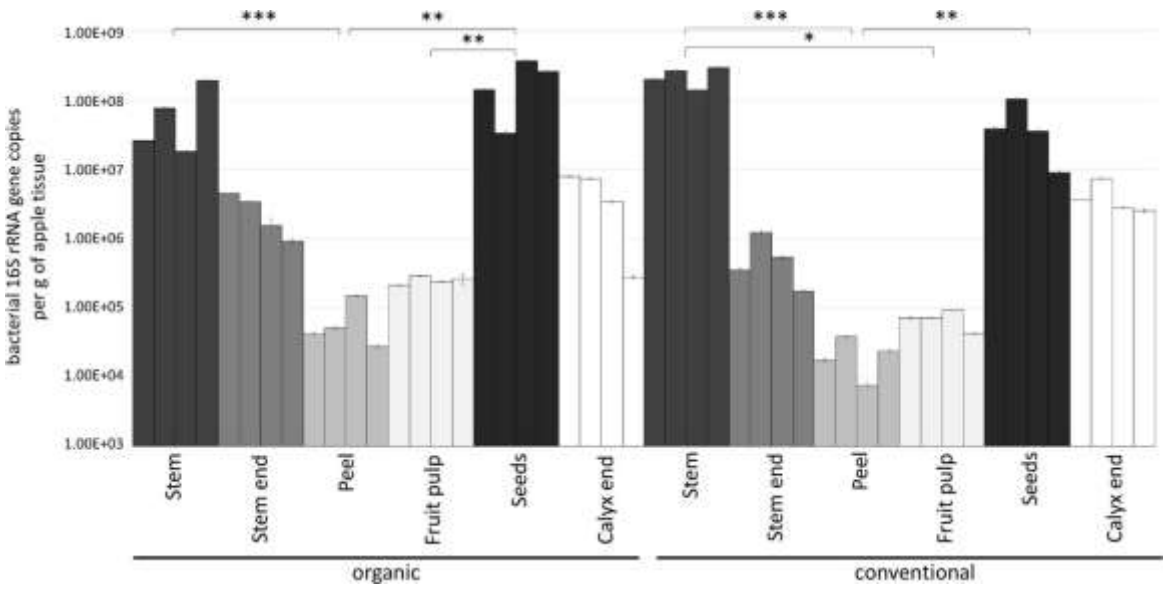
- changed during plants life cycle
- Is specific for plant species
- Was shaped by co-evolution
- Was shaped by breeding
- Has important function for the holo-biont
- Is vertically transmitted by seeds

A healthy plant microbiome is highly diverse, rich and evenly structured.

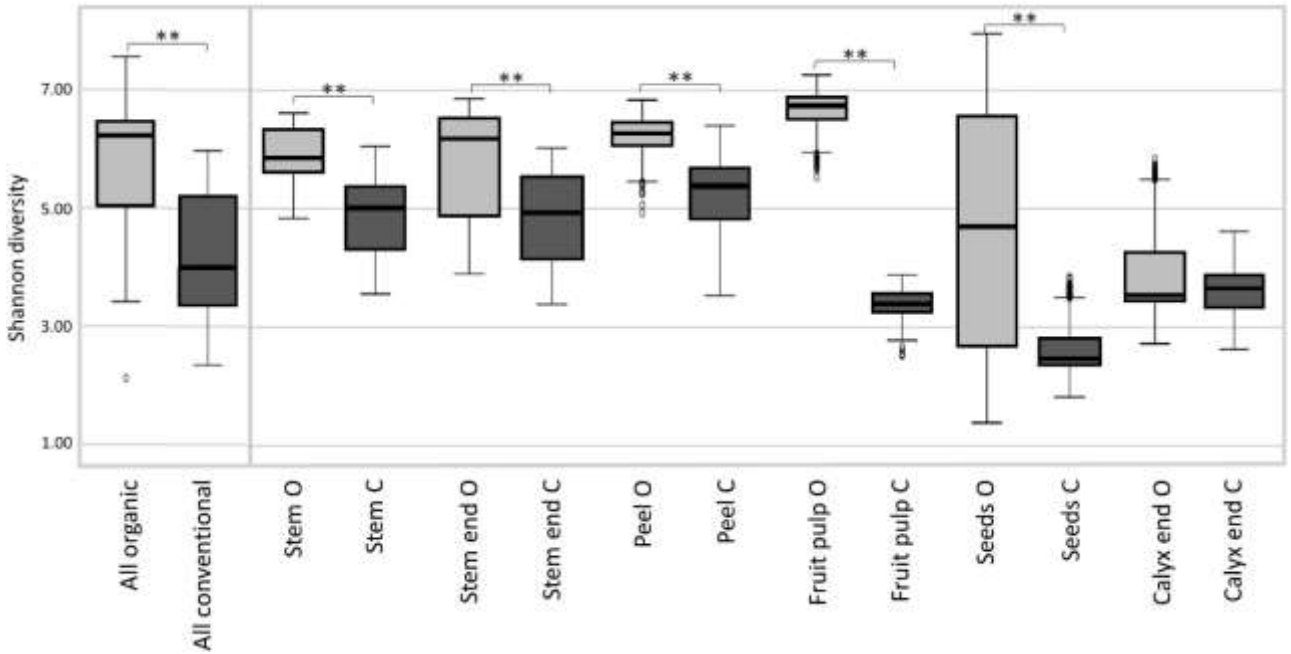
[Berg & Raaijmakers ISME J 2018]

https://apfelmikrobiom.tugraz.at/kunst-konzept/

1. Which microbial biodiversity is associated with apples?

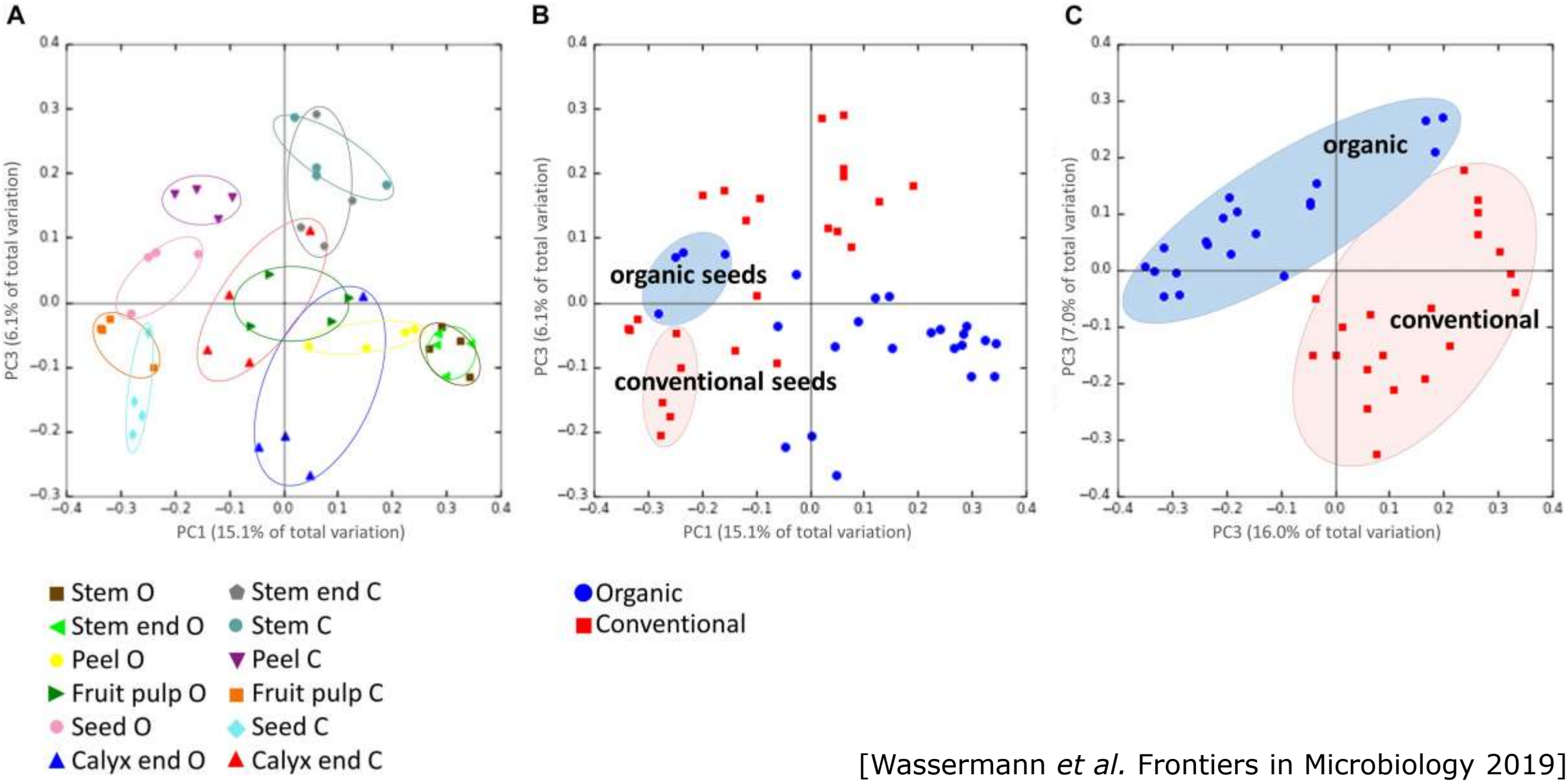


Abundance and diversity



- ✓ 10^8 16S rRNA bacterial gene copy numbers were determined in each g apple
- ✓ fruit pulp and seeds were bacterial hot spots, while the peel was less colonized
- ✓ One apple a day provides more than 100 million bacteria independed of origin
- ✓ Organically produced apples contain a more diverse microbiome
- ✓ One apple a day provides more than 100 million bacteria

1. Which microbial biodiversity is associated with apples?



[Wassermann *et al.* Frontiers in Microbiology 2019]

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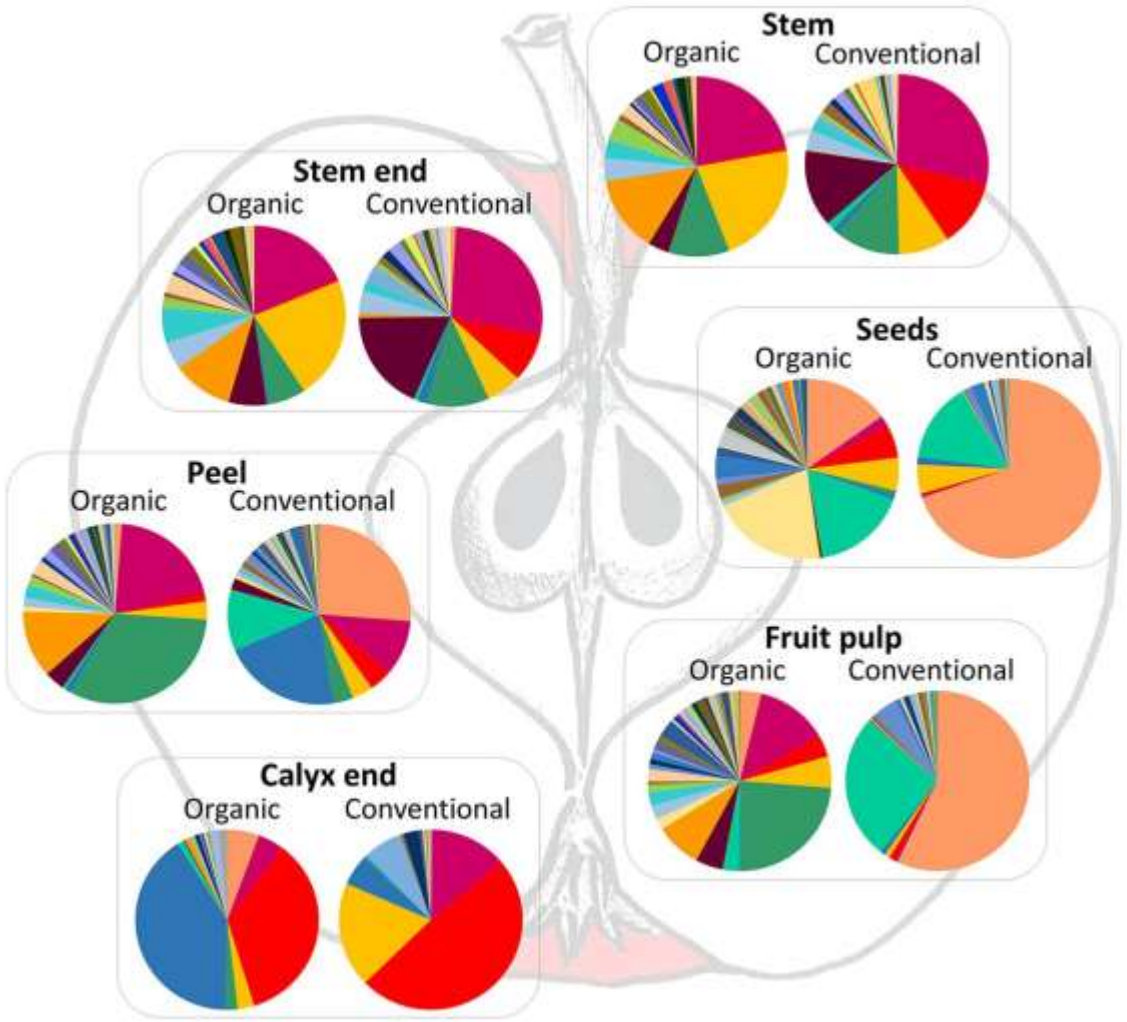
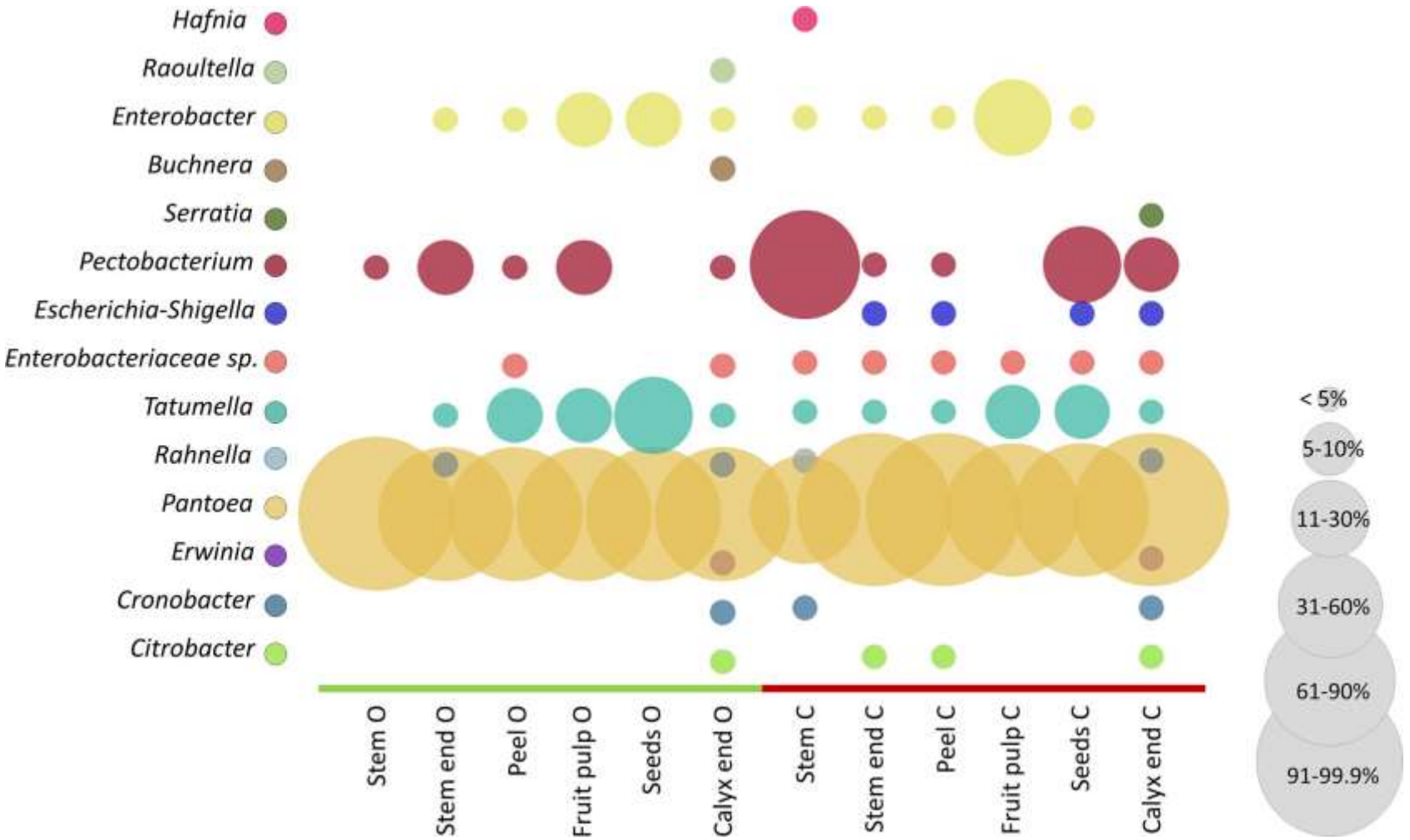


- Ralstonia
- Pseudomonas
- Methylobacterium
- Burkholderia
- Hymenobacter
- Variovorax
- Curtobacterium
- Comamonadaceae sp.
- Acinetobacter
- Pelomonas
- Bdellovibrio
- Flavobacterium
- Kineococcus
- Planctomycetes sp.
- Myxococcales sp.
- Armatimonadetes sp.
- Staphylococcus
- Oligoflexales sp.
- Oxalobacteraceae sp.
- Pedobacter
- Rathayibacter
- Legionella
- Bradyrhizobium
- Paenibacillus
- Microbacteriaceae sp.
- Rhizobiales sp.
- Pectobacterium
- Nitrospira
- Buchnera
- Streptococcus
- Fructobacillus
- Sphingomonas
- Massilia
- Pantoea
- Rhizobiales sp.
- Bacillus
- Mucilaginibacter
- Zymomonas
- Spirosoma
- Frondihabitans
- Acidiphilium
- Novosphingobium
- Acetobacteraceae sp.
- Sphingomonadaceae sp.
- Erwinia
- Rhizobium
- Amnibacterium
- Deinococcus
- Caenimonas
- Sphingobium
- Sorangium
- Gluconobacter
- Aquabacterium
- Corynebacterium
- Acidobacteria sp.
- Chryseobacterium
- Terriglobus
- Stenotrophomonas
- Soil Crenarchaeotic Group(SCG)
- Arthrobacter
- Reyranella

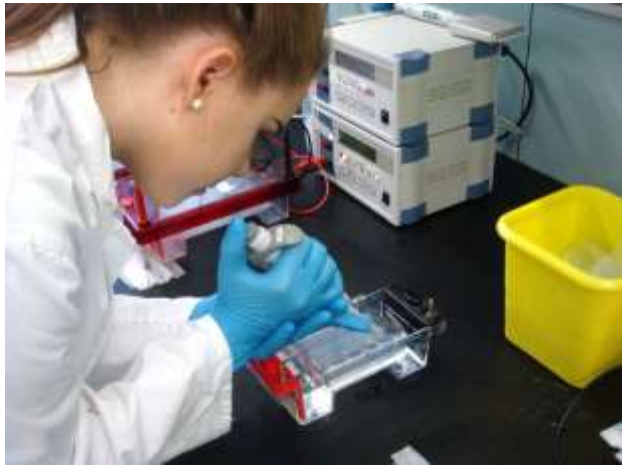
[Wassermann *et al.* Frontiers in Microbiology 2019]

1. Which microbial biodiversity is associated with apples?



[Wassermann *et al.* Frontiers in Microbiology 2019]

Sparkling science: translating science



Microbial diversity on apples is of international interest

TIME

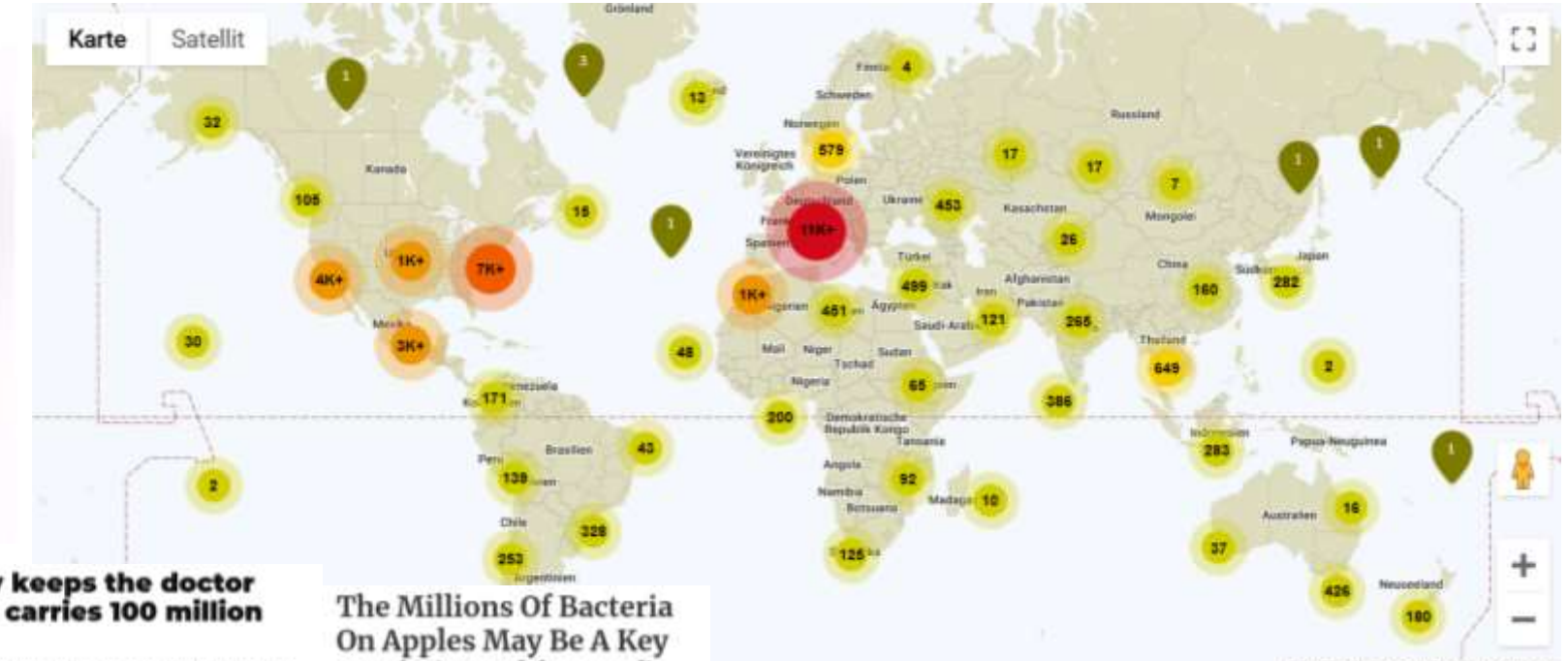
Your Apple Has 100 Million Microorganisms Living On It. Should You Care?

Gut health secret: Have organic apples daily

CNN

Eat the seeds: Why the germs found inside apples may be good for you

By Susan Scutti, CNN



Organic Apples Have Way More Beneficial Bacteria Than Conventional Ones

An apple a day keeps the doctor away, but also carries 100 million bacteria

Sure, apples are bursting with vitamins and antioxidants—but they also carry millions of bacteria that colonise in your gut!

The Millions Of Bacteria On Apples May Be A Key To Their Health Benefits

SPIEGEL ONLINE SPIEGEL

WISSENSCHAFT

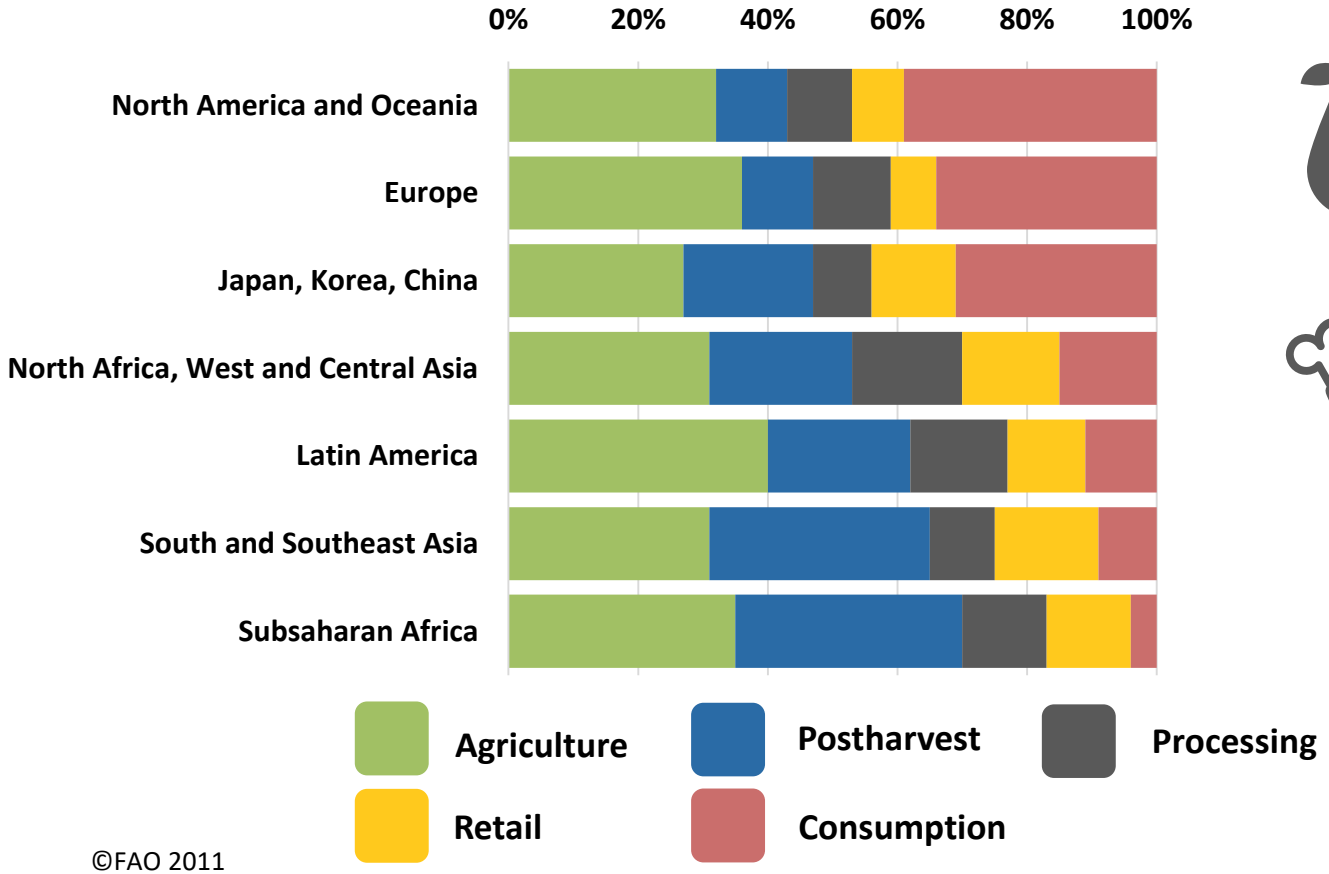
Ernährung

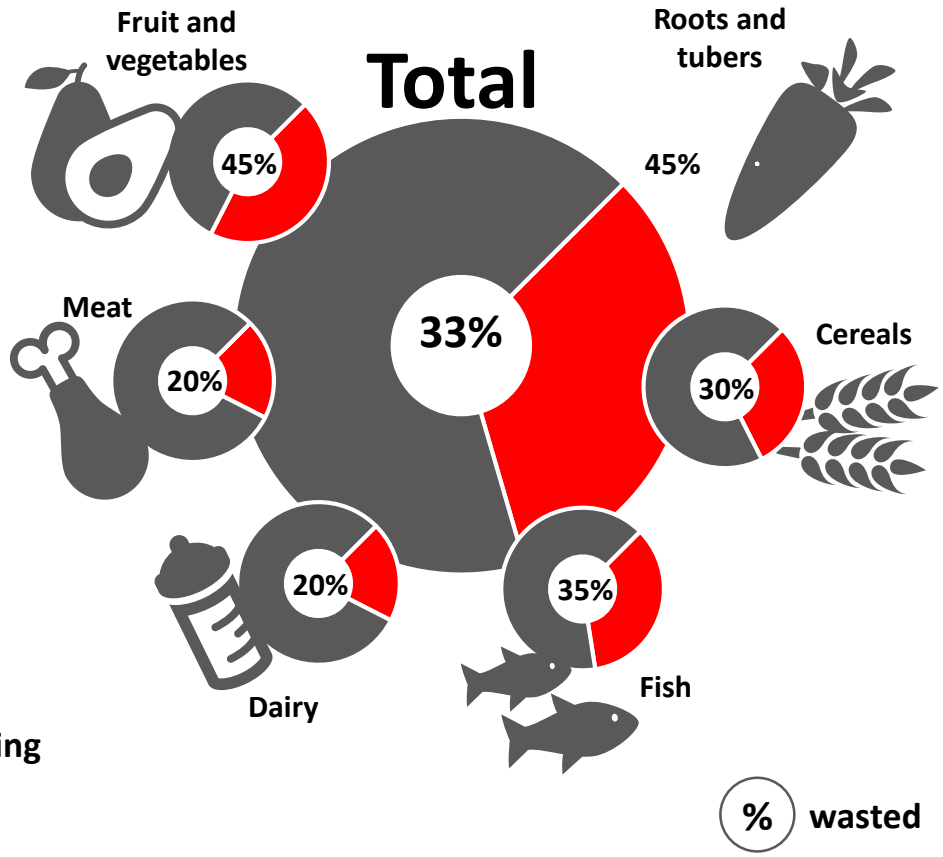
In einem Apfel leben 100 Millionen Bakterien

Äpfel sind nicht nur gesund, weil sie Vitamine enthalten. Das Obst beherbergt auch eine große Anzahl Mikroorganismen, die nach dem Verzehr den Darm besiedeln. Biofrüchte enthalten andere Bakterien als konventionell hergestellte.

PROBLEM: Food loss

Global food loss





2. Is it possible to manage microbial biodiversity?

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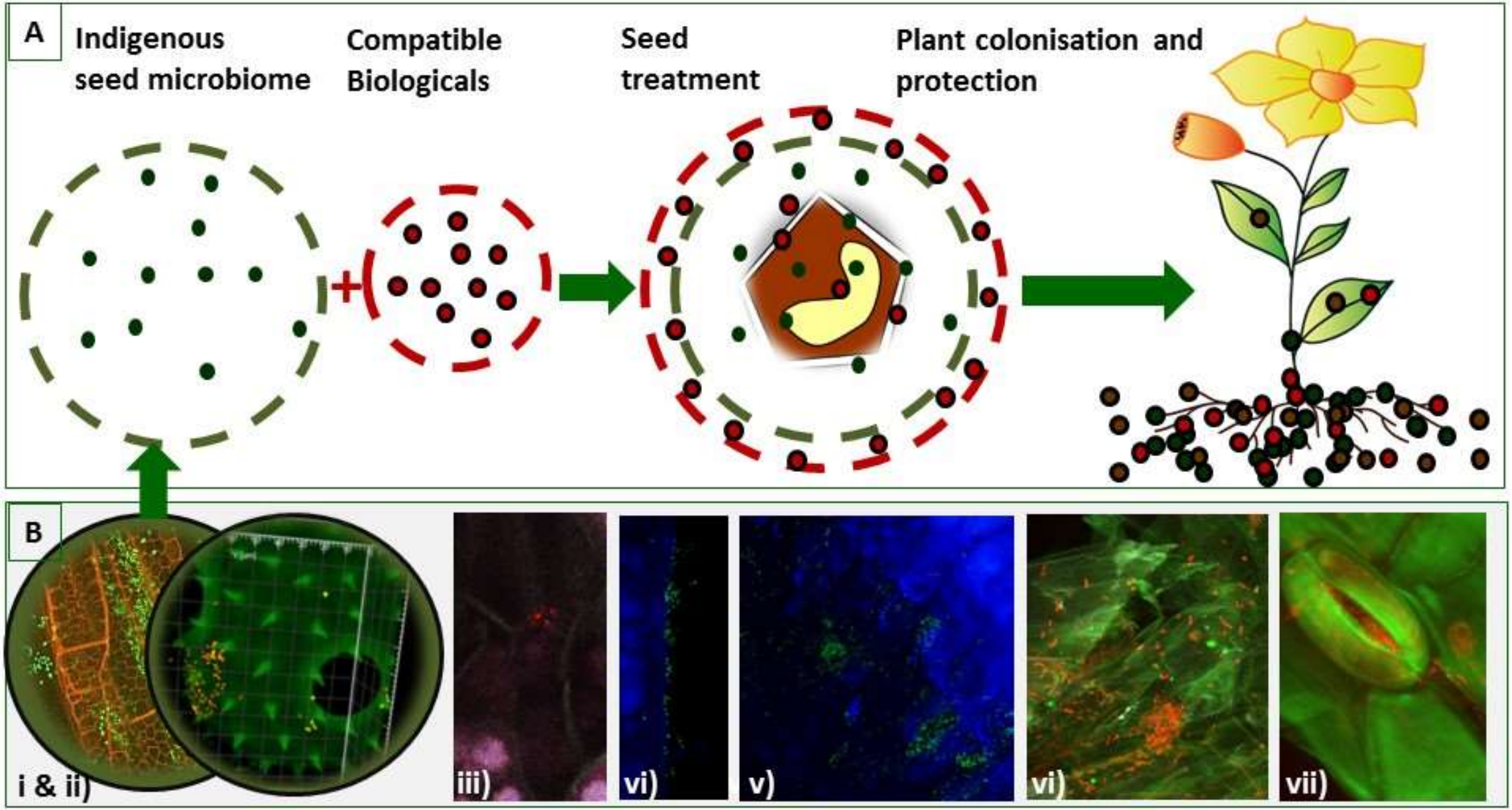
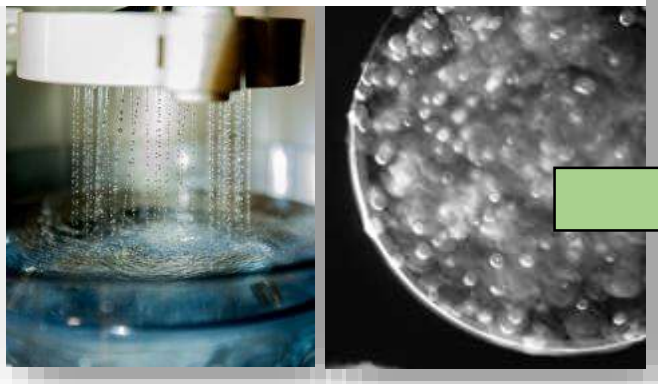


2. Is it possible to manage microbial biodiversity?

biotenzz
Gesellschaft für Biotechnologie mbH



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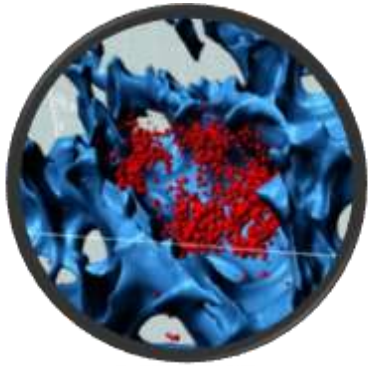

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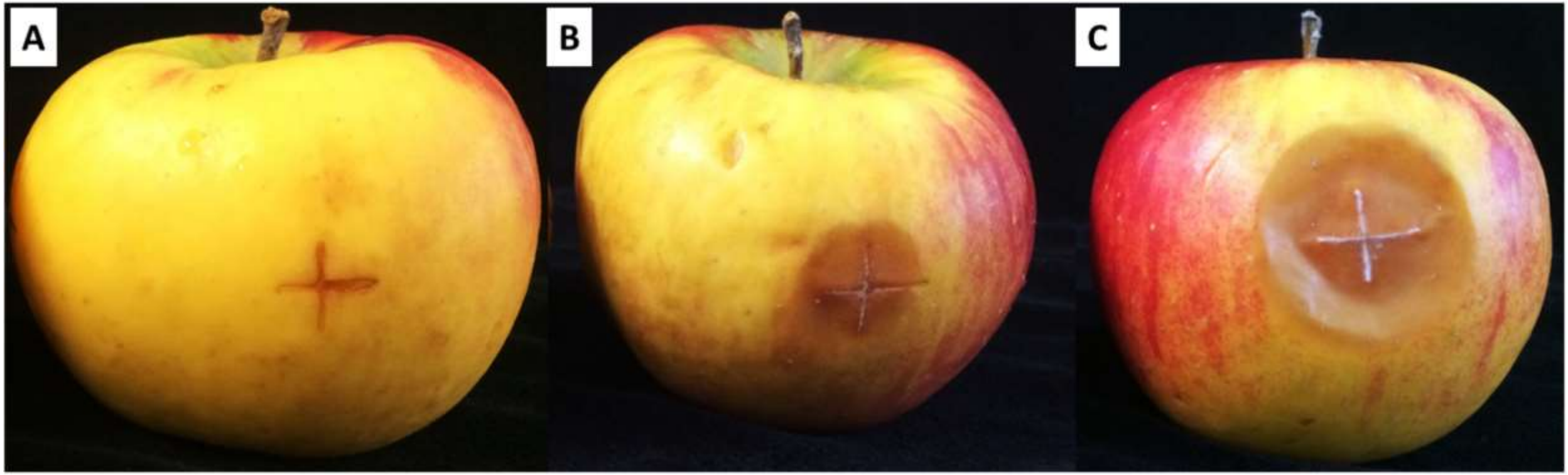


[unpublished results]

2. Is it possible to manage antimicrobial resistances?

uncontrolled

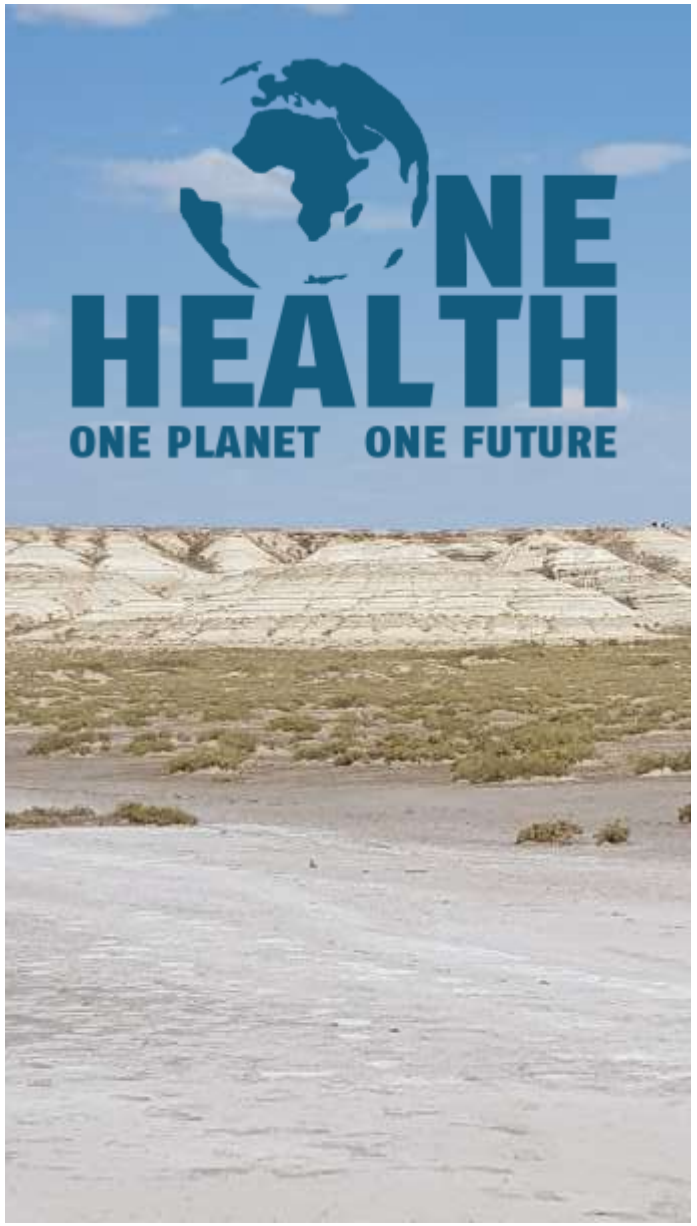
confined

A 50% reduction in diversity on abiotic surfaces led to a 20% increase in antibiotic resistances (P=0.01).

Increased confinement and cleaning resulted in:

- **a loss of microbial diversity by maintained abundance**
- **a shift at superkindom level and from Gram-positive to Gram-negatives**
- **a shift within pan-genomes (*Acinetobacter*)**
- **a larger number of resistance genes**

CONCLUSION: Biodiversity loss world-wide



Plant microbial diversity is a key for all health issues.

The microbiome connects our world.

The microbiome is important for one health issues

The plant microbiota is crucial for *one* health issues

Wissenschaft ruft Schule
Schule ruft Wissenschaft

FFG FWF AUSTRIAN DEVELOPMENT AGENCY bmwfw